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A novel composite radiographic score for longitudinal observational studies of  
Psoriatic Arthritis: Reductive X-ray Score for Psoriatic Arthritis (ReXSPA)- a proof  
of concept study

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## **Abstract**

### **Objective**

To devise a feasible composite radiographic score for use in observational studies of Psoriatic Arthritis (PsA).

### **Methods**

Radiographs from 50 patients with PsA were scored with the PsA-modified Sharp, Sharp-van der Heijde and Ratingen scores. Data reductions were made to devise a concise score.

### **Results**

The Reductive X-ray Score for Psoriatic Arthritis (ReXSPA) requires the assessment of only 22 joints (117 points) including erosion, joint space narrowing and osteoproliferation in the hands and feet. The ReXSPA accounts for 80% of change detected with the Sharp-van der Heijde score.

### **Conclusion**

We report a proof of concept radiographic score for observational studies derived through data reduction.

## Introduction

The measurement of radiographic joint damage is highly valuable in characterising disease severity, progression and prognosis in longitudinal observational studies of psoriatic arthritis (PsA). An essential attribute of a scoring method for use in large longitudinal observational studies is that it can be applied feasibly, within the constraints of cost and time. Existing radiographic measures are time consuming to perform leading to limited data collection from existing longitudinal observational studies. Radiographic damage is frequently reported as the presence or absence of damage. The only radiographic measure currently used on a routine basis is the modified Steinbrocker global score.<sup>1</sup> In the modified Steinbrocker score the radiographic features of soft tissue swelling, osteopenia, erosion, joint space narrowing, lysis and ankylosis are combined in to a single numeric value for each joint. Combining the radiographic features reduces the time taken to perform the score and has the added advantage of following the presumed, but unproven, order of radiographic progression. Composite scores have been developed for use in PsA which require radiographic features to be assessed and scored separately for erosion and joint space narrowing (PsA-modified Sharp Score<sup>2</sup> and the Sharp-van der Heijde score<sup>3</sup>) or erosion and osteoproliferation (PsA Ratingen score<sup>4</sup>). We have previously reported a comparison of the feasibility, reliability and sensitivity to change of these existing radiographic scores used in PsA.<sup>5</sup> The modified Sharp and Sharp-van der Heijde methods were found to be the most reliable and sensitive to change, but took longer to perform. The modified Steinbrocker was the most feasible, taking approximately half the time to score, but lacks the sensitivity of the composite methods.

Our objective was to devise a more feasible composite radiographic score, through a reductive analysis of existing composite scores, for use in large longitudinal observational studies.

#### Materials and Methods:

We have previously reported the details of the patient selection, radiographic techniques and scoring methods used in this study.<sup>5</sup> In brief, standard antero-posterior radiographs of the hands and forefeet from 50 patients with PsA were scored at two time points with each of the PsA-modified Sharp, Sharp-van der Heijde and Ratingen scores.<sup>1</sup> All selected patient's fulfilled the Classification Criteria for Psoriatic Arthritis (CASPAR) criteria.<sup>6, 7</sup> Radiographs were scored by the authors WT and DJ in known chronological order to optimise sensitivity to change and since observational studies usually score radiographs in known order.

Statistical analysis was undertaken in the statistical package R (2014) [<http://www.R-project.org/>]. Analysis was performed on cases who demonstrated progressive disease of any radiographic feature during the follow up period. The aim was to apply data reduction techniques to a dataset consisting of changes (progression) in each of the components of the radiographic scores. Subsets selection using simulated annealing based on principle components analysis<sup>8</sup> was used to find optimal subsets based on the RM coefficient, a measure of the similarity between a reduced dataset and the original. The coefficient ranges from 0 to 1, with larger values indicating strong similarity and higher proportions of explained variation. The fewest number of variables that would give  $RM > 0.9$  was found. Initially, this was performed on the full

dataset using all variables, from all scores, constrained only to make a symmetrical score. A second analysis had the additional constraint that scoring of erosion or joint narrowing had to be consistent within each of the scoring methods. Finally, the analysis was restricted to exclude small wrist joints as these were felt to be time consuming to score and, debatably, less clinically relevant. A number of candidate scoring systems fulfilling the specified criteria performed very similarly (RM coefficients within 0.001). Choosing the final scoring system based on the best performing would have been arbitrary and instead we selected the most ‘clinically reasonable’ scoring system. The performance of the finally derived novel score was assessed according to its ability to predict progression as measured by the PsA-modified Sharp, Sharp-van der Heijde, Ratingen scores.

#### Results:

The patients’ mean age was 54.6 years, mean disease duration 17.6 years and mean follow up 2.1 years. Inter/intra-rater reliability were excellent for all methods (ICC >0.89).<sup>5</sup> Details on the radiographic damage of the cohort are included in a supplementary file (Supp Table 1). The first reduction (the full dataset, restricted only to be symmetrical) identified a score comprising 24 variables. The second analysis (further restricted to only one method of joint space narrowing and erosion, excluding small wrist joints) as detailed in the methods section identified six possible scores of which is reported here (Table 1). The resulting Reductive X-ray Score for Psoriatic Arthritis (ReXSPA) score requires the assessment of only 22 joints and a score out of 117 points. This is compared to 42 variables (168 points) for the modified Steinbrocker or 104 (528 points) for Sharp-van der Heijde score. Within this dataset the ReXSPA score accounts for over 90% of the variance of the full dataset and has a

sensitivity to change of 80% when detecting progression as defined by the most sensitive score, the Sharp-van der Heijde (Table 1).

The joints included in the finally selected model are illustrated in Figure 1 and scales for the measurements in Table 2. Assessment of joint space narrowing and erosion is made using the scale from the Sharp-van der Heijde score and osteoproliferation using the PsA Ratingen scale at the hands, wrist and feet. Ankylosis was only scored in the Sharp-van der Heijde joint space narrowing score.

## Discussion

We propose a novel composite radiographic score for longitudinal observational studies that is sensitive to change and includes three hallmark features of PsA, erosion, joint space narrowing and osteoproliferation. This novel score requires fewer joints to be assessed than the other most commonly used score in observational studies, the PsA-modified Steinbrocker, whilst maintaining a similar sensitivity to change as the Sharp-van der Heijde score.

Global scores are briefer and quicker to perform but have the significant disadvantage of combining data into a single numeric value. Raw data on individual radiographic features (domains) is therefore not available for future sub-analysis. In comparison composite scores have the advantage of being more sensitive to change and able to preserve the data relating to specific radiographic features. For example, data may be required from existing cohorts for a genetic association study where specificity of joint damage is the most important attribute. A composite score allows for separate analysis of erosion or, in the case of the Ratingen score, osteoproliferation, the only

radiographic feature sufficiently specific to PsA to be included in the classification criteria for psoriatic arthritis (CASPAR) criteria.<sup>6</sup>

The ReXSPA is a tool proposed for observational cohorts to allow large scale data collection. We believe that none of the existing scores are optimal for use in the observational setting. The modified Steinbrocker may be considered feasible (readily learned and applied in our dataset in a mean of 6.2 minutes) but it is not sufficiently sensitive to change, does not allow sub-analysis of individual radiographic features, does not include osteoproliferation, and scores for osteopenia, which is both rare in PsA and prone to inter-rater variability.<sup>5</sup> The Sharp-van der Heijde score is sensitive to change and readily learned, but takes more than twice as long to perform (mean of 14.4 minutes in our dataset), the difference between scoring nearly ten films in an hour versus four.<sup>5</sup>

A strength of the approach we have taken in this present study is to allow the data (sensitivity to change) to determine the final score, however we recognise other approaches could have been taken. It would be possible to reduce an existing score, such an approach has been adopted with the Psoriatic Arthritis Impact of Disease score with two versions available, 9 and 12 domains.<sup>9</sup> The Sharp-van der Heijde score may seem the most suitable method for this approach but would not include osteoproliferation which is specific to PsA and has been shown to be sensitive to change.<sup>5</sup> Alternatively the Ratingen score does not include joint space narrowing, which is clinically relevant and sensitive to change. On this basis, we believe that using the full dataset of all variables (joint space narrowing, erosion and osteoproliferation from all joints) with data driven selection has justified our



approach. Though this present study is large for a comparison of radiographic measures, the score has been derived from a small group of patients and needs to be applied in the clinical setting in a larger dataset. Furthermore, the ReXSPA score remains a proposal derived from the existing dataset and feasibility and reliability are yet to be formally determined. Finally the radiographs were scored in known chronological order. Whilst this is consistent with the intended clinical use in the observational setting (and optimizes sensitivity to change) the approach has the potential to introduce expectation bias.

In conclusion, we report a proof of concept radiographic score for observational studies in PsA derived through data reduction. The composite ReXSPA score has a similar sensitivity as the Sharp-Van der Heijde, the most sensitive method developed, but is briefer than the modified Steinbrocker, the most feasible method. This ReXSPA score can now be further assessed in larger studies.

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## Ethics

The study was approved by the Bath Research Ethics Committee and has been conducted in accordance with the Declaration of Helsinki. All participants signed informed consent.

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**Table 1-** Correlation, sensitivity and area under curve analyses of the novel ReXSPA score compared with existing methods.

Score	<b>Spearman Correlation coefficient</b>	<b>Sensitivity</b>
Any change (full dataset)		0.77
VDH	0.88	0.80
MSS	0.84	0.82
Ratingen	0.67	0.86
VDH Erosion	0.75	0.96
MSS Erosion	0.73	0.96
Ratingen destruction	0.62	0.95
VDH joint space narrowing	0.69	0.79
MSS joint space narrowing	0.69	0.84
Ratingen proliferation	0.54	0.86

VDH: Sharp-Van der Heijde

MSS: Modified Sharp score

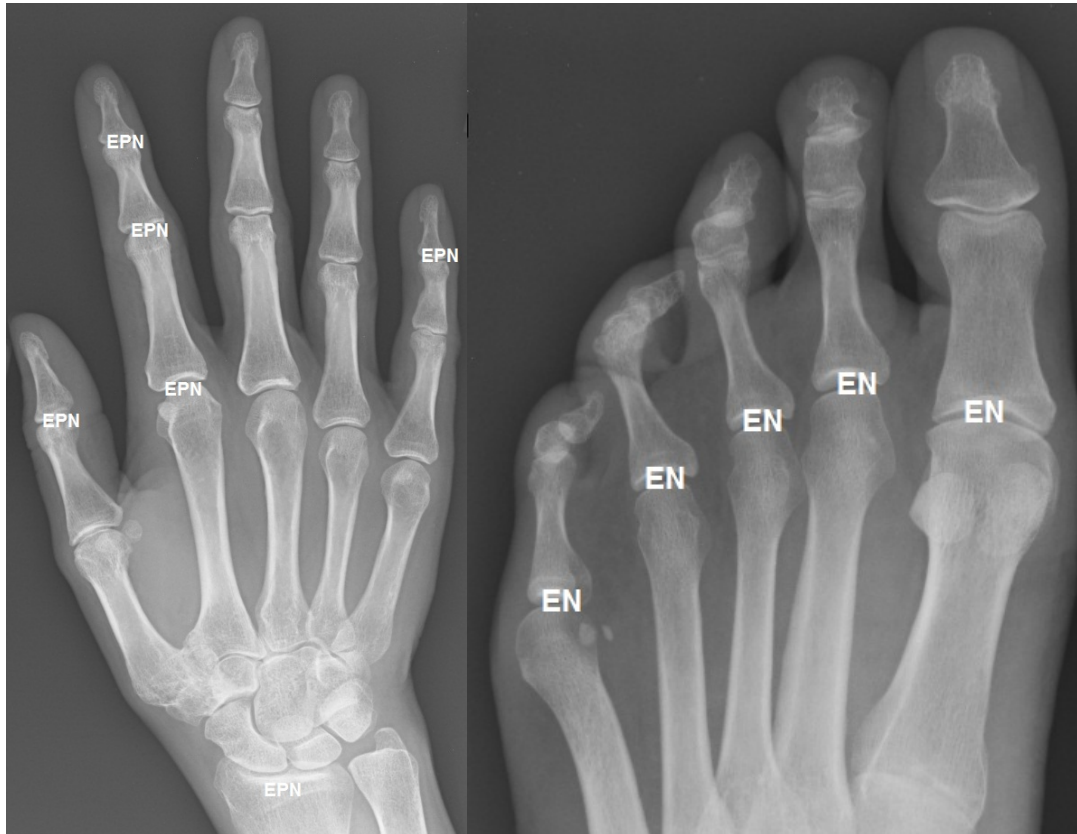
ReXSPA: Reductive X-ray Score for Psoriatic Arthritis

Sensitivity is defined as the ability to predict progression in a patient defined as any recorded change in the given scoring system.

**Table 2 – ReXPSA score scales**

<b>P=proliferation</b>  <b>From PsA Ratingen score</b>	<b>E=erosion</b>  <b>From Sharp-van der Heijde</b>	<b>N=joint space narrowing</b>  <b>From Sharp-van der Heijde</b>
0 = normal.	0 = no erosions.	0 = normal
1 = bony proliferation measured from the original bone surface of 1-2mm, or clearly identifiable bone growth not exceeding 25% of the original diameter of the bone.	1= discrete erosion.	1 = asymmetrical minimal narrowing with loss of up to a maximum of 25%
2 = bony proliferation of 2-3mm or bone growth between 25 to 50%	2 = large erosion not passing the midline.	2 = definite narrowing with loss of up to 50% of the normal space
3 = bony proliferation >3mm or bone growth >50%	3 = large erosion passing the mid-line.	3 = definite narrowing with loss of 50 – 99% of the normal space or subluxation
	4 = combination of above	4 = absence of a joint space, presumptive evidence of ankylosis, or complete subluxation.
	5 = combination of above	
Proliferation score /18 points	Erosion score /55 points	Joint space narrowing score /44 points
Total score /117		

Figure 1 Joints assessed in the ReXPSA score



E: Erosion

P: Osteoproliferation

N: Joint Space Narrowing